SWRHL-16r

# FINAL REPORT OF OFF-SITE SURVEILLANCE FOR THE NRX-A2 EXPERIMENT

by the
Southwestern Radiological Health Laboratory
U. S. Public Health Service
Department of Health, Education, and Welfare
Las Vegas, Nevada

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## ABSTRACT

The Public Health Service provided off-site surveillance in support of the NRX-A2 reactor tests conducted on September 24 and October 15, 1964. This support consisted of tracking the effluent, monitoring radiation dosage to the off-site population, and collecting environmental samples (air, milk, water and vegetation). Analyses of these data indicate that no hazard was created to the off-site population from the NRX-A2 tests.

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# INTRODUCTION

As a part of the ROVER Program, testing and disassembling of a series of reactors designated NRX-A is being carried on under the Nuclear Engine for Rocket Vehicle Application (NERVA) Project at the Nuclear Rocket Development Station. The subject of this report is the off-site surveillance provided by the Public Health Service (PHS) for the Atomic Energy Commission (AEC) in support of the NRX-A2 experiments conducted at Test Cell A on September 24 and October 15, 1964. Each test will be covered in a separate section of this report.

Under a Memorandum of Understanding with the Atomic Energy Commission, the U. S. Public Health Service conducts a program of radiological monitoring and environmental sampling in the off-site area surrounding the Nevada Test Site and the Nellis Air Force Range. The overall complex of the Nevada Test Site (NTS) and the Nellis Air Force Range (NAFR) includes the Nuclear Rocket Development Station (NRDS) and the Tonopah Test Range (TTR) and for simplicity will be called the test range complex throughout this report.

Since Public Health Service monitors must begin tracking and monitoring an effluent cloud close to its point of origin, measurements are also made within the test range complex, but are used only as a guide to trajectory determination or for purposes of checking instrumentation and methodology. They did not serve as parameters in determining dose to people or contamination of property in the off-site area during the NRX-A2 tests and are not a subject of this report.

## Section 1. NRX-A2 EPIV, September 24, 1964

## I. OPERATIONAL PROCEDURES

On September 24, the reactor was tested under the conditions known as Experimental Plan IV (EPIV) and was operated at design power from 1055 to 1105 PDT. The reactor was tested in an upright position so that the hydrogen coolant exhausted upward along with escaping fission products.

### A. External Measurements

#### Ground Monitoring

Thirteen ground monitors tracked the reactor effluent passage with portable instruments. Each monitor was equipped with an Eberline E-500B, a Precision Model 111 Standard "Scintillator", and a Victoreen Radector Model No. AGB-50B-SR.

The Eberline E-500B has a range of 0 to 200 milliroentgens per hour (mr/hr) gamma and beta-gamma detection in four scales with an external halogen filled GM tube and a 0 to 2000 mr/hr range from an internal Anton 302 tube. The Precision Model 111 "Scintillator" is used primarily for low level detection and provides for a range of 0 to 5 mr/hr in six scales. The Radector has a range of 0 to 50,000 mr/hr on two scales. This instrument employs an air ionization chamber. These instruments are accurate to $\pm$ 20%, and readings can be taken to two significant figures.

#### Remote Dose Rate Recorders

Eberline RM-11 dose rate recorders were placed at sixteen stations around the test range complex. These recorders utilize a Geiger tube detector to document radiation levels at specific locations. The instrument has a 0.01 to 100 mr/hr range and the

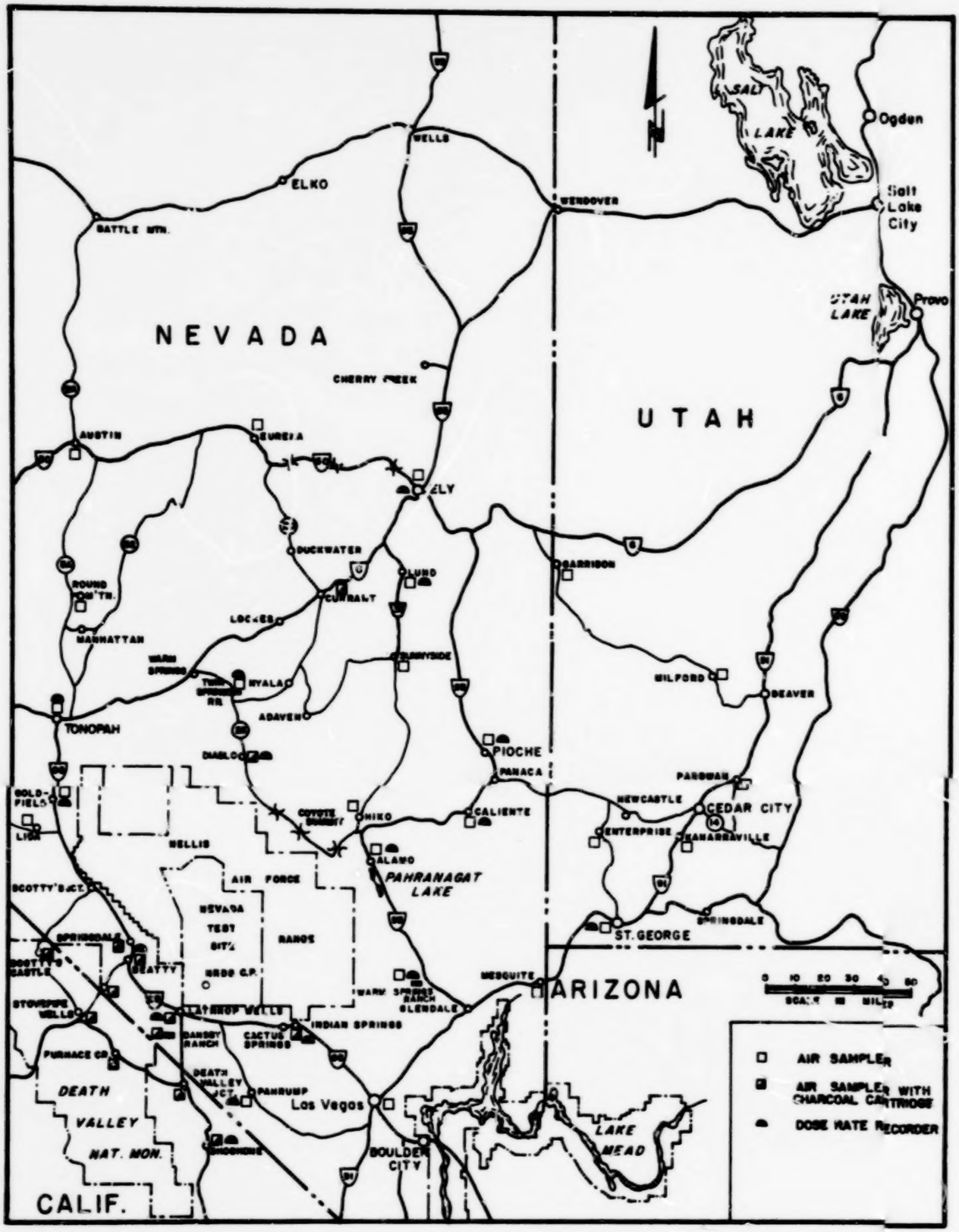


Figure 1. Location of air samplers and dose rate recorders for NRX-A2 EPIV.

gamma dose rate is recorded on a 30-hour strip chart. The RM-11 is accurate to ± 20% as calibrated with a $Co^{60}$ source. The locations of dose rate recorders are presented in Figure 1.

Aerial Cloud Tracking

An Air Force U-3A aircraft, manned by two Public Health Service monitors equipped with portable instruments identical to those of the ground monitors, tracked the reactor effluent to position ground monitors. Two Public Health Service C-45 aircraft containing sampling equipment were also used as aids in cloud tracking. However, their primary purpose was cloud sampling in order to determine cloud size and inventory. The results of their sampling are reported separately.

Film Badges

The PHS maintains 65 film badge stations off the test range complex and assigns badges to 166 off-site residents. The badge used is made up of Dupont Type 555 film. This film is accurate to ± 50% in the 20 to 100 mr range and ± 10% in the 100 to 2000 mr range.

B. Environmental Measurements

Air Samples

On the test day the PHS maintained General Metal Works high volume air samplers containing glass fiber prefilters at 36 off-site locations as shown in Figures 1 and 2. Thirteen of the air samplers were equipped with MSA* charcoal cartridges in addition to the prefilters. All air sample prefilters collected following the NRX reactor runs were returned to the Southwestern Radiological Health Laboratory (SWRHL) in Las Vegas to be counted for gross beta activity with a thin window, large area

*Mine Safety Appliance Company

Figure 2. Location of air samplers and dose rate recorders for NRX-A2 EPV.

proportional probe connected to a high speed scaler. The system has an efficiency of approximately 30% for 1.5 Mev betas and has a background of 575 $\pm$ 20 counts per minute.

Gross beta concentrations were computed at the time of count for the purpose of screening samples and delineating the effluent trajectory. These samples were then stored for five days to allow natural activity to decay. They were recounted at this time and again seven days later. Activity levels were then recomputed to end of collection from these two later counts. Several air samples exhibiting levels of activity significantly above natural background were recounted frequently to obtain a decay curve. The curve obtained was then analyzed for best fit to the general equation $y=ax^b$. Based on an analysis of decay curves, a $T^{-1.25}$ relationship was found to exist with a mean error of $\pm$ 5%. This relationship was then used to extrapolate the activity to the end of the collection period.

All charcoal cartridges were analyzed for gamma isotopes by placing each cartridge directly on a 4" x 4" sodium iodide crystal coupled to a 400-channel pulse height analyzer set to view energies from 0 to 2 Mev. Assuming no break in the prefilter, the activity on the cartridge should represent the gaseous fission products such as isotopes of iodine. Overall detection efficiency for this geometry is about 18% at 0.53 Mev ($I^{133}$). The minimum detectable activity for $I^{131}$, $I^{132}$, $I^{133}$, and $I^{135}$ is taken to be 200 picocuries with an associated error of $\pm$ 50% for $I^{131}$, $I^{132}$, $I^{133}$, and $\pm$ 100% for $I^{135}$. The time of count is 10 minutes. Error estimates are such that values less than 1 picocurie per cubic meter ($pc/M^3$) are generally not reported. Since it is not possible to define duration of effluent passage at all locations,

the reported values given as $pc/M^3$ assume an average concentration over each entire sampling period.

## Milk and Water Samples

After each release of activity from NRDS, milk samples are collected from dairies (processing plants), producing dairy farms, and farms producing milk for their own consumption. Milk samples were collected, relative to this event, from the locations shown in Figure 2. Each sample was counted for 50 minutes. No attempt was made to recount samples giving low positive values. The lower limit of detection for gamma emitters in milk samples is taken to be 20 picocuries per liter (pc/l) at the time of count, and all results below that value are reported as <20 pc/l. The error associated with reported values is $\pm$ 20 pc/l. All reported values are extrapolated to collection time.

All liquid samples are counted in 3.5 liter inverted well aluminum beakers which are placed on top of a 4"x4" crystal coupled to a 400-channel gamma pulse height analyzer. Overall detection efficiency for the 0.364 Mev photo-peak of $I^{131}$ is 6.4%. A matrix technique is employed in computation to compensate for the interference due to the presence of other isotopes. The input to this matrix is variable, allowing for the simultaneous determination of any eight nuclides for which detection efficiencies and interference factors have been obtained. Actual computation is performed by an IBM 1620 computer.

## Vegetation Samples

Vegetation samples were obtained at most milk sampling locations. An attempt was made to make the samples representative of the cow's feed; however, the samples were taken primarily

as early indicators of where milk might be contaminated and were not intended to yield a cow intake-excretion formula. For this reason the vegetation samples are reported simply as fresh fission products present or not present.

## II RESULTS

Experimental Plan IV resulted in low levels of radioactivity being detected off the test range complex. Radiation monitors were positioned in an area southwest of the test area according to information furnished by aerial monitors and the U. S. Weather Bureau. (See Table 2).

### A. Ground Monitor Data

Gamma dose rates above background were detected in the vicinity of Lathrop Wells, on Highway 95, and at Dansby's Ranch located 10 miles southwest of Lathrop Wells. (See Table 1 below). Lathrop Wells has a population of about fifty people. Monitoring at these places on the day following the test produced only background readings. Monitors were also called upon to check the off-site area during the night following the test when activity was detected on the NRDS. Readings above background were found off the test range complex for five miles along Highway 95 starting nine miles northwest of Lathrop Wells. The maximum reading of 0.12 mr/hr was found 9.8 miles NW of Lathrop Wells at approximately 0100 hours on September 25.

Table 1. Dose rates occurring off the test range complex on September 24, 1964.

| Location (See Fig. 1) | Time of Peak Dose Rate (PDT) | Time of dose rates greater than background | Net Peak Dose Rate (mr/hr) |
|---|---|---|---|
| Lathrop Wells | 1234 | 1215-1500 | 0.43 |
| Dansby's Ranch | 1320 | 1250-1450 | 0.07 |
| Hwy 95(4.5 mi NW of Lathrop Wells) | 1220 | 1240-1330 | 0.23 |

Table 2. Meteorological Data for EPIV

Upper Air Data: Jackass Flats, Nevada, 1100 PDT, September 24, 1964

| Height (Ft. MSL) | Wind (Deg/Kts) | Pressure (mb) | Temperature (°C) | Dew Point (°C) | Relative Humidity (%) |
|---|---|---|---|---|---|
| SFC | 070/18 | 895 | 28.6 | - 0.6 | 15 |
| 4000 | 060/22 | 883 | 25.0 | - 3.4 | 15 |
| 5000 | 060/13 | 854 | 22.7 | - 2.7 | 18 |
| 6000 | 080/11 | 824 | 20.0 | - 3.6 | 20 |
| 7000 | 040/04 | 794 | 17.3 | - 4.0 | 23 |
| 8000 | 030/04 | 768 | 15.3 | - 4.2 | 26 |
| 9000 | 090/08 | 738 | 12.9 | - 4.6 | 29 |
| 10000 | 090/08 | 712 | 10.7 | - 5.6 | 31 |
| 11000 | 098/11 | 687 | 8.0 | - 7.6 | 32 |
| 12000 | 080/12 | 662 | 5.5 | - 9.1 | 34 |
| 13000 | 073/18 | 638 | 3.6 | -12.6 | 29 |
| 14000 | 070/19 | 614 | 1.7 | -18.8 | 20 |

B. Dose Rate Recorder Data

The recorder at Lathrop Wells indicated radioactivity associated with effluent from the NRX-A2 test on September 24. This instrument recorded a net peak dose rate of 0.18 mr/hr at 1230 hours PDT. The time interval in which the dose rate exceeded background was 1210 to 1340 hours and the estimated external dose during cloud passage was 0.08 mr.

C. Film Badge Data

Due to the low dose rates encountered at points south and west of the test range complex, no off-site film badges were collected immediately following the NRX-A2 test. Badges collected since that time, however, have had no exposure which could be attributed to the EPIV test.

D. Air Sample Data

Several samples taken following the test contained fresh fission products. The results of analysis of the prefilters and charcoal cartridges are presented in Table 3.

Table 3. Analysis of air samples containing fresh fission products collected following the NRX-A2 EPIV Experiment reported in pc/$M^3$ at end of collection.

| Location | ON Time-Date PDT | OFF Time-Date PDT | Volume ($M^3$) | Prefilter Gross Beta Activity | | Gamma Pulse Height Analysis $I^{131}$ | $I^{133}$ | $I^{135}$ |
|---|---|---|---|---|---|---|---|---|
| Lathrop Wells | 0715, 9-24 | 1455, 9-24 | 261 | 450 | P | 13 | 57 | 84 |
| | | | | | C | <1 | 42 | 37 |
| | 1500, 9-24 | 0715, 9-25 | 553 | 2.3 | P | | | |
| | | | | | C | ND | <1 | ND |
| Dansby Ranch | 1050, 9-24 | 1550, 9-24 | 183 | 420 | P | 12 | 55 | 82 |
| | | | | | C | <1 | 45 | ND |
| Death Valley Jct. | 0940, 9-24 | 1500, 9-24 | 211 | 2.5 | P | | | |
| | | | | | C | ND | ND | ND |
| | 1500, 9-24 | 0625, 9-25 | 642 | 2.2 | P | | | |
| | | | | | C | ND | <1 | ND |
| Stovepipe Wells | 1045, 9-24 | 1500, 9-24 | 181 | <1 | P | | | |
| | | | | | C | ND | ND | ND |
| | 1510, 9-24 | 1030, 9-25 | 804 | 1.5 | P | 0.5 | 2.4 | 3.5 |
| | | | | | C | <1 | 4.9 | ND |
| Furnace Creek | 1100, 9-24 | 1500, 9-24 | 146 | 3.6 | P | | | |
| | | | | | C | ND | ND | ND |
| | 1510, 9-24 | 0955, 9-25 | 750 | 19 | P | 0.5 | 2.4 | 3.5 |
| | | | | | C | <1 | 3.9 | ND |

P=prefilter C=charcoal cartridge ND=not detectable

Air samples taken on September 24 at Scotty's Castle. Beatty and Springdale showed no fresh fission products when analyzed.

E. Milk Sample Data

Milk samples obtained on the test day and the two following days at Dansby's Ranch indicated low levels of $I^{133}$. Iodine-131 was not present in detectable quantities. Dansby's Ranch is 22 miles southwest of Test Cell A. Six other milk samples collected did not contain fresh fission products in detectable quantities. (See Table 4). The cesium values reported are within the range of the cesium levels generally found in the particular areas sampled.

F. Water Sample Data

Water samples collected on the day of the test at Dansby's Ranch and the day after the test at the Watson and Selbach Ranches near Lathrop Wells, Lathrop Wells Gas Station, Furnace Creek and Stovepipe Wells did not show detectable levels of radioactivity.

Table 4. Analyses of milk and vegetation samples collected following NRX-A2 EPIV

| COLLECTION DATA | | Milk Radioassay Data | | | |
|---|---|---|---|---|---|
| LOCATION (Azimuth and Distance from Test Cell A) | DATE COLLECTED 1964 | ACTIVITY (pc/l) $I^{131}$ | ACTIVITY (pc/l) $I^{133}$ | ACTIVITY (pc/l) $Cs^{137}$ | Vegetation Samples Taken |
| Dansby Ranch<br>Lathrop Wells<br>225° 22 mi. | 9-24 | <20 | 200 | 20 | P |
| | 9-25 | <20 | 70 | 30 | P |
| | 9-26 | <20 | 20 | 20 | P |
| | 9-27 | <20 | <20 | 25 | --- |
| Hunter's Ranch<br>Olancha, California<br>248° 100 mi. | 9-26 | <20 | <20 | 65 | ND |
| Lone Pine Dairy<br>Lone Pine, California<br>261° 98 mi. | 9-26 | <20 | <20 | 40 | ND |
| M&R Cattie Company<br>Cantil, California<br>221° 140 mi. | 9-27 | <20 | <20 | 40 | ND |
| Hills Dairy<br>Barstow, California<br>200° 140 mi. | 9-27 | <20 | <20 | 20 | ND |

ND=fresh fission products not present in vegetation.
P=presence of fresh fission products in vegetation samples.
---=vegetation samples not taken.

## III CONCLUSIONS

The NRX-A2 test of September 24, 1964, yielded low levels of radioactivity to the off-site area. The effluent was encountered in a small area of the Armagosa Desert between Death Valley Junction, Stovepipe Wells, and the NRDS. Fresh fission products were detected as far away as Stovepipe Wells (45 miles) and Furnace Creek (40 miles) in the form of radioiodines on air filters. In both cases the concentrations were less than five picocuries per cubic meter of air. The maximum levels of radioactivity detected off the test range complex were found at Lathrop Wells, Nevada. These levels of 0.43 mr/hr net gamma and 450 $pc/M^3$ of gross beta activity were not considered health hazards to the population.

Environmental samples collected following the test did not show detectable amounts of radioactivity more than thirty miles from NRDS. Only one milk cow was in the effluent path within 80 miles of the test area. This cow was located at Dansby's Ranch which is 22 miles southwest of Test Cell A and eight miles southwest of Lathrop Wells, Nevada. Although the milk from this cow was not used for human consumption at the time of the test, samples were taken for several days following NRX-A2 EPT. This milk contained no $I^{131}$ in detectable quantities and the peak $I^{133}$ concentration was 200 pc/l which occurred on the day of the test. Since this milk sample was collected only two to three hours after cloud passage, the $I^{133}$ found in the milk was evidently due to inhalation.

## Section 2. NRX-A2 EPV, October 15, 1964

### I. OPERATIONAL PROCEDURES

The reactor was tested under the conditions known as Experimental Plan V (EPV) on October 15, 1964 at 1210 hours PDT. The test was approximately a twenty minute run at less than 20 per cent of design power. The reactor was in an upright position so that the fission products exhausted upward.

The operational procedures followed on this experiment were similar to those used in support of the September 24 test.

## II. RESULTS

On October 15, 1964 Experimental Plan V was conducted with low levels of radioactivity being detected northeast of the test range complex. A summary of weather conditions at 1230 on the test day is presented in Table 5.

### A. Ground Monitor Data

Due to the low dose rates encountered by aerial monitors, no ground monitors were positioned off the test range complex. However, ground monitors located on the test range complex downwind from the reactor encountered no readings above background.

### B. Dose Rate Recorder Data

RM-11 recorder charts collected following NRX-A2 EPV indicated no dose rates above background.

### C. Film Badge Data

Due to the low dose rates encountered, no film badges were collected immediately following the NRX-A2 test. Badges collected since that time, however, have had no exposures which could be attributed to the EPV test.

### D. Air Sample Data

Only one off-site air sample contained detectable quantities of fresh fission products. The charcoal cartridge at Indian Springs showed 150 total picocuries of $I^{131}$. This sample was started at 1800 on the test day and the air sampler motor failed during the night. However, if the sampler ran for only two hours, 150 total picocuries would be less than one picocurie per cubic meter

on the filter. Although the effluent from EPV went to the northeast, it is believed that northerly drainage winds carried some radioactivity to the south during the night resulting in radioiodine being detected at Indian Springs.

Table 5. Meteorological data for EPV.

Upper air data at: Jackass Flats, Nevada, 1230 PDT, October 15, 1964

| Height (Ft. MSL) | Wind (Deg/Kts) | Pressure (mb) | Temperature ($^{o}$C) | Dew Point ($^{o}$C) | Relative Humidity (%) |
|---|---|---|---|---|---|
| SFC | Calm | 892 | 28.3 | - 1.8 | 14 |
| 4000 | 250/02 | 880 | 26.8 | - 2.0 | 15 |
| 5000 | 220/02 | 850 | 23.3 | - 2.4 | 18 |
| 6000 | 180/02 | 821 | 20.4 | - 3.4 | 20 |
| 7000 | 140/01 | 791 | 17.5 | - 4.0 | 23 |
| 8000 | 180/02 | 752 | 14.6 | - 4.8 | 26 |
| 9000 | 180/04 | 735 | 12.1 | - 5.0 | 30 |
| 10000 | 170/05 | 711 | 9.1 | - 6.0 | 34 |
| 11000 | 180/08 | 686 | 6.4 | - 6.3 | 40 |
| 12000 | 180/12 | 659 | 3.2 | - 7.3 | 46 |
| 13000 | 170/16 | 634 | 0.8 | - 6.3 | 51 |
| 14000 | 180/16 | 611 | - 1.9 | -11.0 | 50 |

E. Milk Sample Data

Milk samples were collected at Lund, Nevada on October 16 and at Alamo and Hiko on October 20. These samples did not contain detectable quantities of fresh fission products.

F. Water Sample Data

A water sample collected from a water trough at Goss Ranch on October 16 contained 75 pc/l of $I^{133}$. No $I^{131}$ was detectable in the sample.

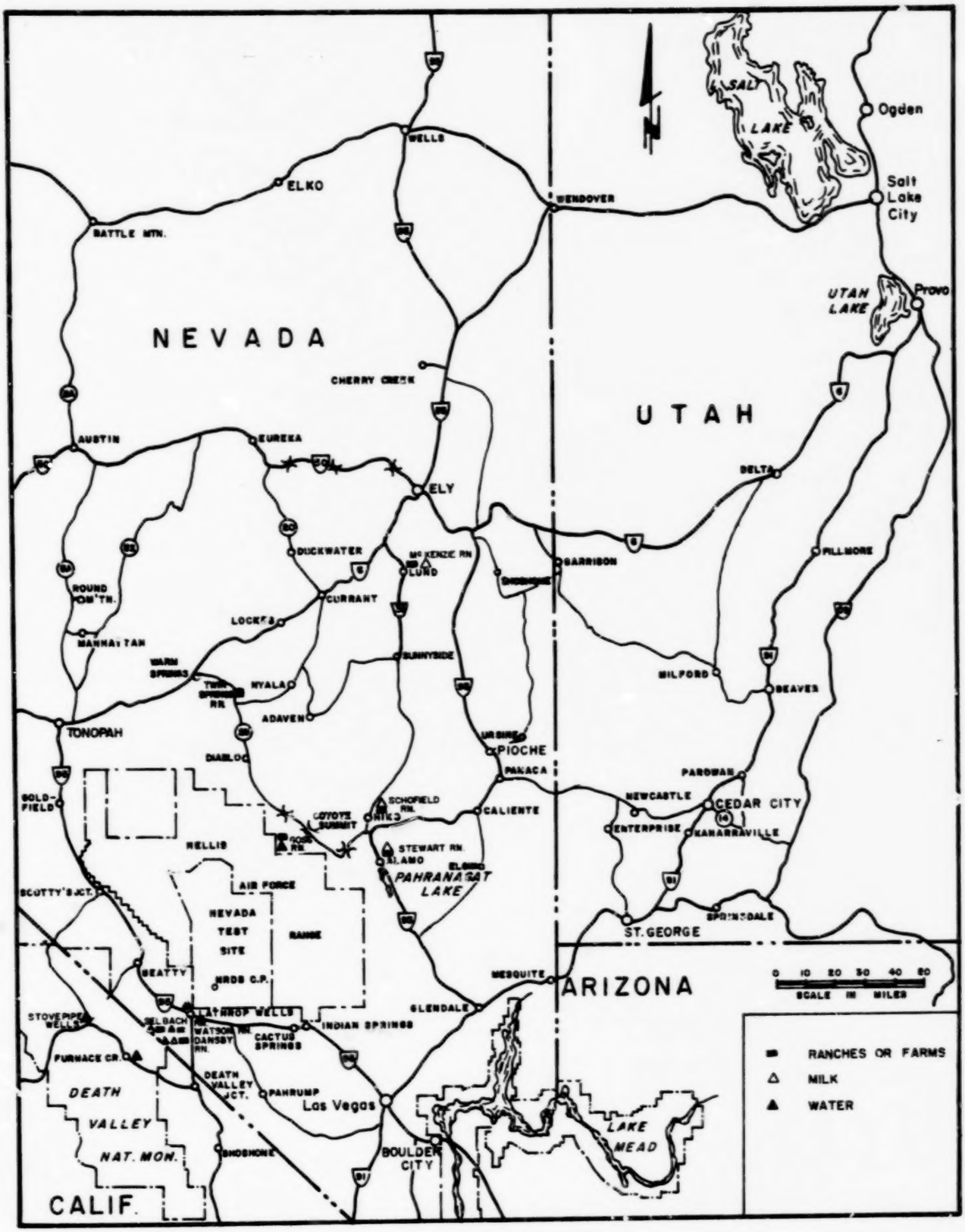


Figure 3. Environmental sampling locations for EPIV and EPV.

G. Vegetation Sample Data

In order to determine cloud trajectory, vegetation samples were collected at Goss Ranch, Hiko and Alamo, Nevada. The samples from Goss Ranch and Hiko contained low levels of fresh fission products.

## III. CONCLUSIONS

The NRX-A2 EPV experiment of October 15, 1964, yielded low levels of radioactivity off the test range complex. The effluent was found in an area northeast of the test range complex between Test Cell A and Hiko, Nevada.

Low levels of fresh fission products were found on vegetation samples collected at Goss Ranch and Hiko and in a water sample from Goss Ranch but no radioactivity was found in milk sampled at Hiko, Lund and Alamo. It is concluded that the radioactivity from this test did not constitute a hazard to the off-site population.